

# Status of the ESO/ELT programme

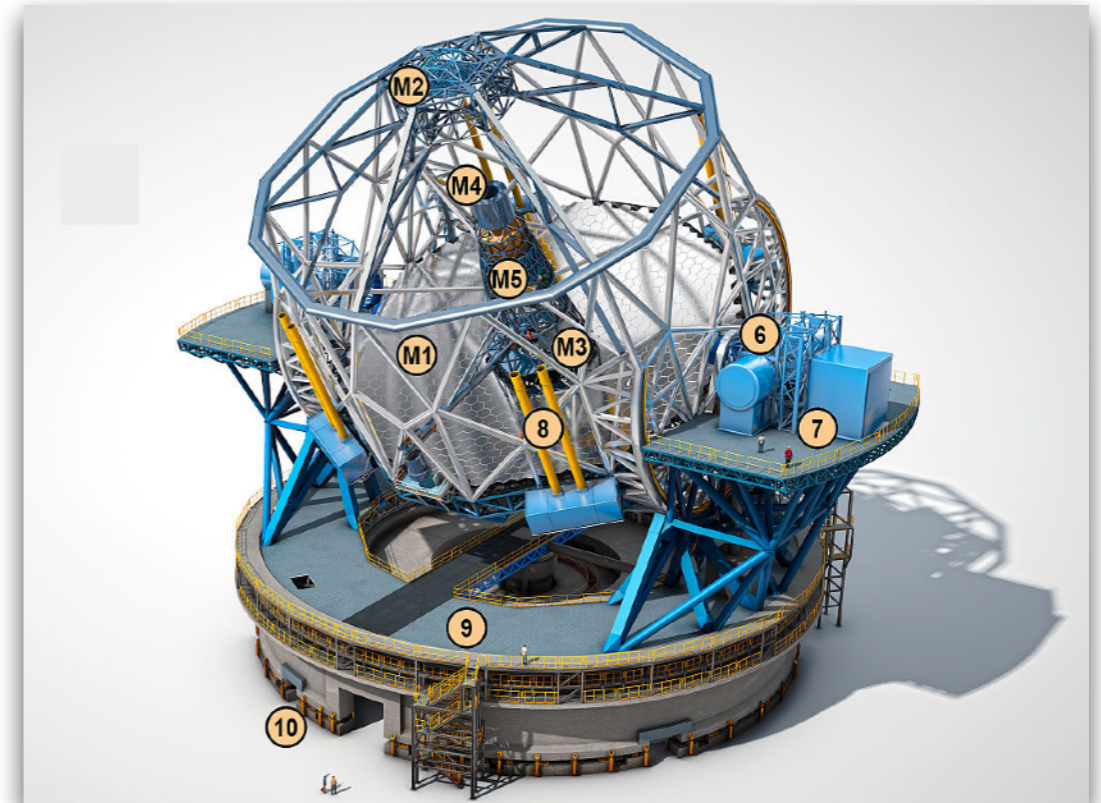


Alexis Coleiro | Journées PNHE | 06/09/2023



# Extremely Large Telescope (ELT)

- Largest optical/infrared telescope in the world
  - 39m-diameter telescope (segmented primary mirror)
  - First consideration by ESO in 2005
  - Project approved by ESO Council in 2012
  - Construction work started mid-2014 (Cerro Armazones - Chile)





# Status & planning



2018

Construction start

2019

Start of the mirror manufacturing (First segment M1)

2025

End of dome building

2026

Mirror installation

2028

First light





# Status & planning





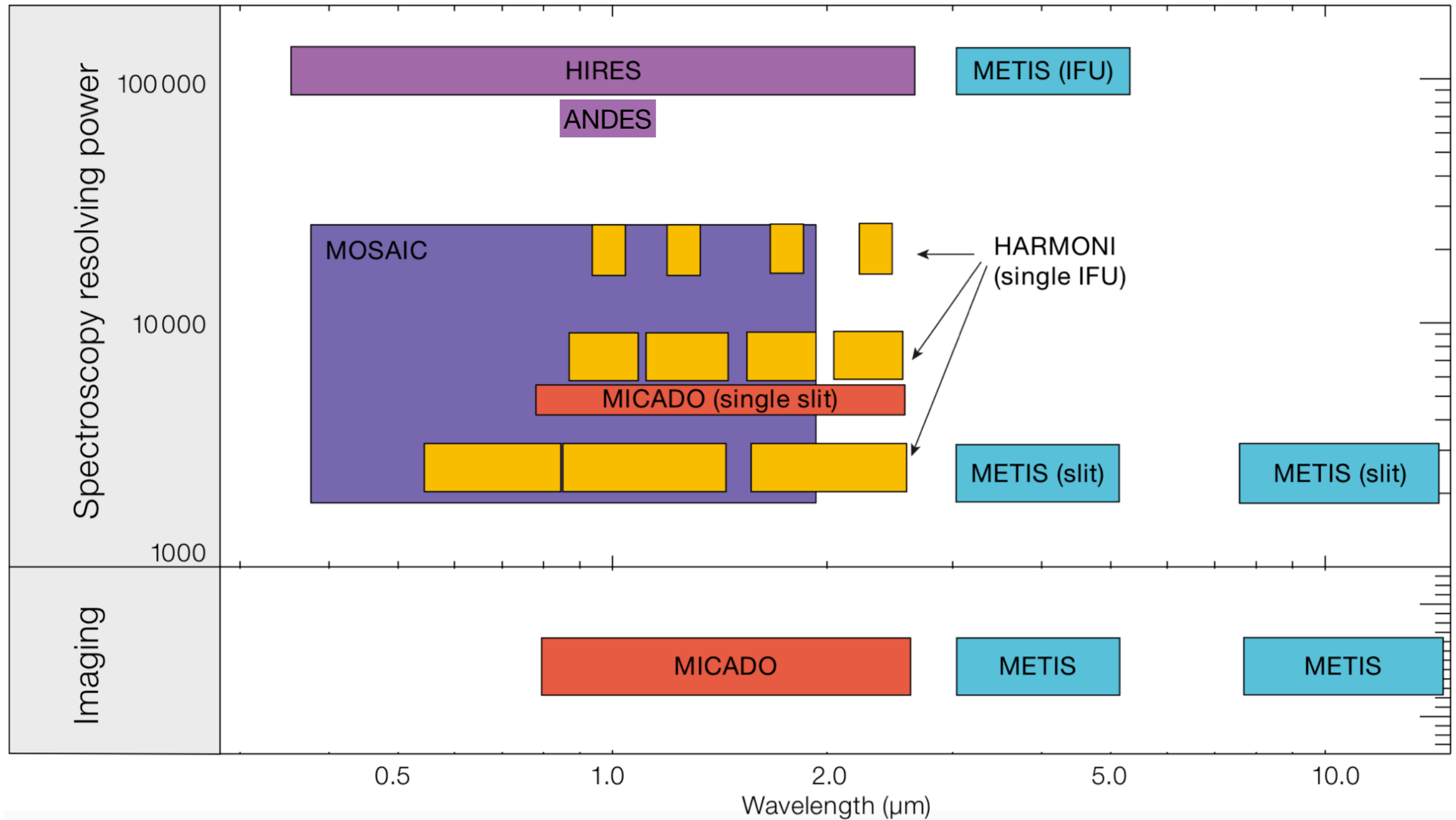
# Science cases (among others)

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- Exoplanets: direct imaging + atmosphere characterisation for biomarker molecules
- Formation of planetary systems
- First galaxies (formation and evolution)
- Study of early phases of star formation + **SN and GRB in the early Universe ( $z \sim 7-15$ )**
- **Black holes: Galactic center, search for IMBH, SMBH feedback**
- Mapping of the expansion history of the Universe
- Probe of possible variations in the fundamental constants



# Instruments





# Instruments

Instrument	Main specifications			Schedule				
	Field of view/slit length/ pixel scale	Spectral resolution	Wavelength coverage ( $\mu\text{m}$ )	Phase A	Project start	PDR	FDR	First light
MICADO	Imager (with coronagraph) 50.5" $\times$ 50.5" at 4 mas/pix 19" $\times$ 19" at 1.5 mas/pix	<i>I, Z, Y, J, H, K</i> + narrowbands	0.8–2.45	2010	2015	2019	2023	2025
	Single slit	$R \sim 20\,000$						
MORFEO	AO Module SCAO – MCAO		0.8–2.45	2010	2015	2022	2024	2026
HARMONI + LTAO	IFU 4 spaxel scales from: 0.8" $\times$ 0.6" at 4 mas/pix to 6.1" $\times$ 9.1" at 30 $\times$ 60 mas/pix (with coronagraph)	$R \sim 3\,200$ $R \sim 7\,100$ $R \sim 17\,000$	0.47–2.45	2010	2015	2018	2024 ?	2026
METIS	Imager (with coronagraph) 10.5" $\times$ 10.5" at 5 mas/pix in <i>L, M</i> 13.5" $\times$ 13.5" at 7 mas/pix in <i>N</i>	<i>L, M, N</i> + narrowbands	3–13	2010	2015	2019	2022	2024
	Single slit	$R \sim 1\,400$ in <i>L</i> $R \sim 1\,900$ in <i>M</i> $R \sim 400$ in <i>N</i>						
	IFU 0.6" $\times$ 0.9" at 8 mas/pix (with coronagraph)	<i>L, M</i> bands $R \sim 100\,000$						
ANDES	Single object	$R \sim 100\,000$	0.4–1.8 simultaneously	2018	2024 ?	2026 ?	2028 ?	2030 ?
	IFU (SCAO)							
	Multi object (TBC)							
MOSAIC	$\sim 7$ -arcminute FoV $\sim 200$ objects (TBC)	$R \sim 5\,000$ –20 000	0.45–1.8 (TBC)	2018	?	2030 ?	2032 ?	2034 ?
	$\sim 8$ IFUs (TBC)	$R \sim 5\,000$ –20 000	0.8–1.8 (TBC)					
PCS	Extreme AO camera and spectrograph	TBC	TBC	2020	2025	2028	2030	2032

First light instruments

First generation instruments (~2035 ?)

PDR = Preliminary Design Review

FDR = Final Design Review



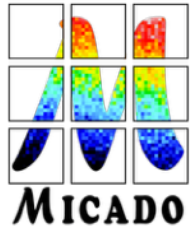
# French involvement

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- ELT = among INSU « ground instrument priorities » with strong manpower investment
- INSU prospective 2019: « *La priorité est d'assurer le financement de l'instrumentation ELT et de consolider le PI-ship français de MOSAIC tout en continuant à développer des instruments VLT/I complémentaires* ».
- **P0 priority:**
  - 1st light instruments: HARMONI, MICADO, MORFEO, METIS
  - 1st generation instruments: MOSAIC (PI: INSU)
  - CNRS & CEA strongly involved in the design and development of the instruments (adaptive optics, control system, pipelines, ...)
- **P1 priority:** ANDES (+ PCS ?)
- **Since 2022:** comités de suivi: technical monitoring of the projects
- **Scientific activities:** need to strengthen coordination and scientific preparation at French community level: **involvement of each Programme National**



# Science cases



Near-infrared camera with spectroscopic capabilities (PI: MPE)



Adaptive optics coupled with MICADO (PI: INAF)

## Imaging

- Star formation history of galaxies through resolved stellar population
- Galaxy formation and evolution in the early universe
- Closeby galactic nuclei (stellar formation, BH, ...)

## Astrometry

- Proper motion of stars within some light hours from SgrA\*
- IMBH in stellar clusters and dwarf galaxies
- Milky Way formation

## Spectroscopy

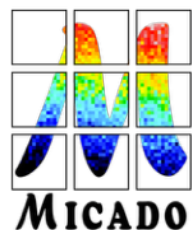
- Ages, metallicity, masses of first elliptical galaxies ( $z \sim 2-3$ )
- Spectra of first SN
- Redshifts, velocity and metallicities of galaxies at  $z \sim 4-5$

## High-contrast imaging

- Giant planets at some AU of host star
- Direct detection of planets discovered through radial velocities



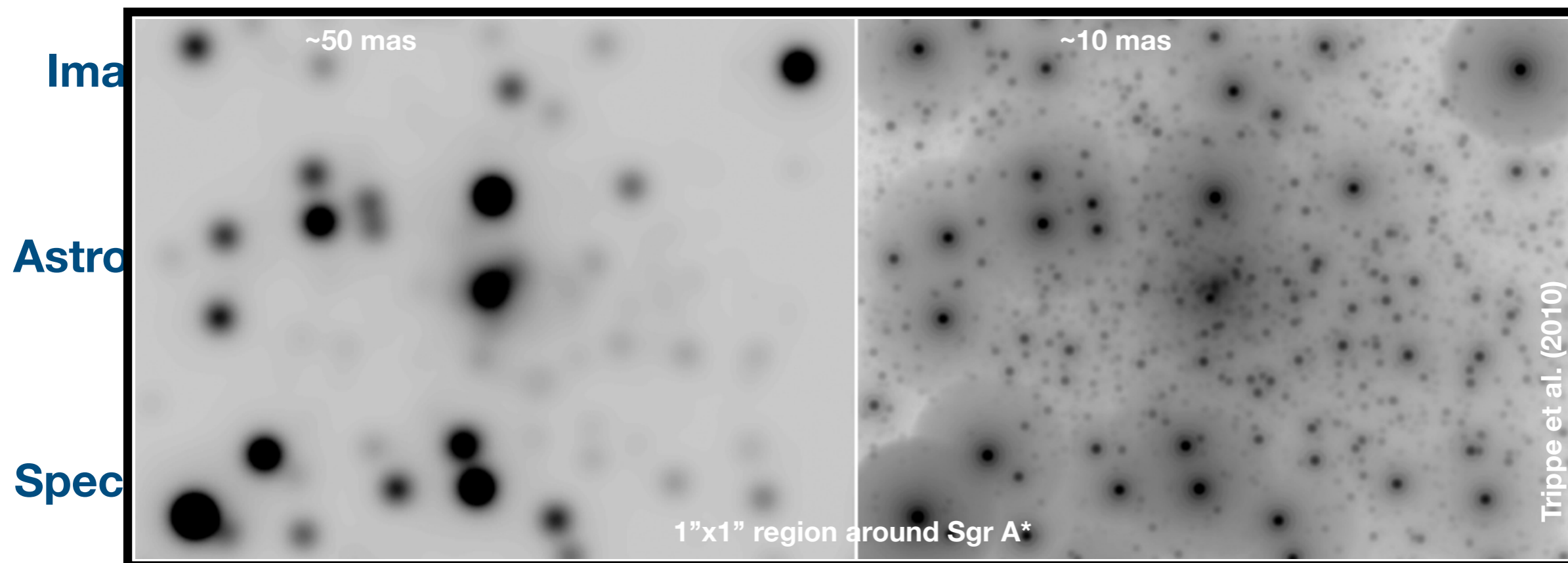
# Science cases



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## High-contrast imaging

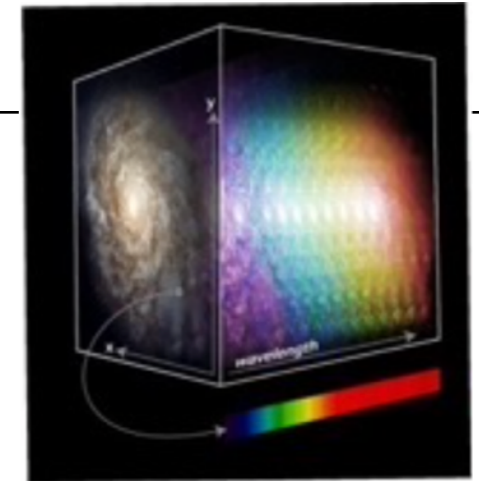
- Giant planets at some AU of host star
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# Science cases



Infrared integral-field spectrograph  
(PI: UK - deputy PI: Fr)



## Organization by Working Groups



Unveiling the properties of the black hole's host galaxy, for example the bulge mass and stellar velocity dispersion

# Science cases



## Mid-infrared imager and spectrometer (PI: Leiden)

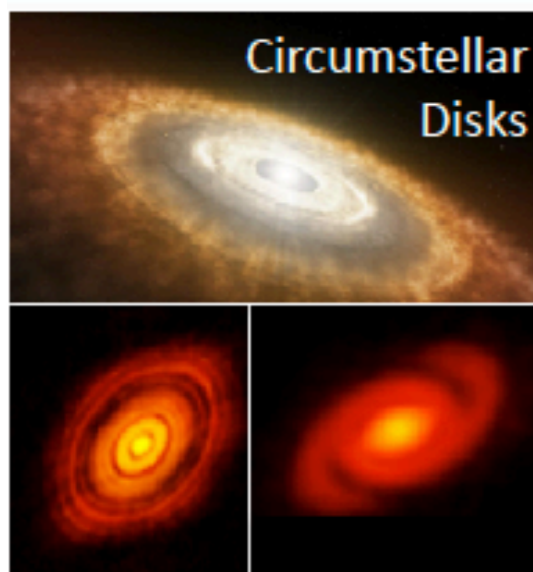
*Fills the gap between JWST and terrestrial interferometers in terms of resolution and sensitivity.*

### Main scientific drivers:

- exoplanets (L&M imaging mainly, N band to some extent, spectroastrometry HRS L/M)
- protoplanetary disks (N band, L/M HRS)
- debris disks (N band imaging mainly)

### Other science

- AGNs (needs LGS) & Active galaxies & SSCs, strongly limited by lack of LGS
- SNs
- protostars
- embedded stars (high mass binaries)
- evolved stars
- solar system





# Science cases



Very high spectral resolution spectrometer  
(PI: Leiden)

- WG1** 45 me. **Exoplanets:** characterization of Exoplanet atmosphere - detection of signature of life  
**Protoplanetary discs:** dynamics - chemistry - physical conditions in the inner regions
- WG2** 23 me. **Stellar populations:** metal enrichment and dynamics of extragalactics star cluster - resolved stellar populations  
**Stellar astrophysics:** abundance of solar-type and cooler dwarfs in galactic disc bulge - halo and nearby dwarfs: tracing metal enrichment of Pop III stars in nearby universe
- WG3** 20 me. **Intergalactic medium:** signature of reionization and early enrichment of ISM - IGM observed in high-z quasar spectra **Super massive black hole: low-mass end** (Spectro-astrometry)  
**Galaxie evolution:** massive early type galaxies epochs of formation and assembly
- WG4** 12 me. **Fundamental physics:** variation of fundamental constants -  $\alpha$ ,  $m_p/m_e$ , Sandage test

→ Important intérêt Exoplanètes dans le ST et en France

WG on transient sources ?

medium resolution  $R \sim 60,000$  mode (TBC)

# Science cases

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MOSAIC

**Multi-object spectrometer (PI: LAM / GEPI)**

**WG1: First light galaxies & reionisation**

**WG2: Inventory of matter**

**WG3: Mass assembly of galaxies**

**WG4 & 5: Stellar populations in and beyond the Milky Way**

**WG6: Transients & Multi-messenger (cf. S. Vergani)**



# Actions to be taken

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- Common tools + training need (sharing expertise, especially on data simulators)
- Cross-instrument synergies
- Development of centers of expertise or centers dedicated to data reduction / preparation of observing programs (*à la* JMMC ?)
- ELT day at French level

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- ELT day at French level
- **At PNHE level:**
  - Identify needs and interests (don't hesitate to contact me !)
  - Survey on the use of ESO instruments and prospects with the ELT
    - *Current use of ESO facilities ? **20%***
    - *Will your future PNHE research require the use of ELT data ? ⇒ **Yes: ~14% ; Don't know: ~53%***
  - ⇒ Webinars, workshops dedicated to HE science cases ?
  - Etc.



# Backup slides

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# Back-up: french involvement

## Lots de travaux français des instruments ELT

Un grand nombre de synergies

- **HARMONI :** **106,4 ETP (2021-2026)**
  - Optiques adaptatives (SCAO, LTAO)
  - Analyseurs de surface d'onde pour les étoiles laser
  - Unité intégrale de champ
  - Banc haut contraste
  - Logiciel de réduction
  - Contrôle-commande (EFISOFT)
  - Intégration et tests du *top end*
- **MICADO :** **50,5 ETP (2021-2026)**
  - Optique adaptative (SCAO)
  - Calculateur temps-réel
  - Contrôle-commande (EFISOFT)
  - Module haut contraste
- **MAORY :** **27,8 ETP (2021-2028)**
  - Analyseurs de surface d'onde pour les étoiles laser
- **MOSAIC :** **166 ETP (2021-2028)**
  - Fibres
  - Spectrographe proche-infrarouge
  - Logiciel de réduction
  - Contrôle-commande (EFISOFT)
  - Intégration et tests
- **METIS :** **20,2 ETP (2021-2026)**
  - Cryo-mécanismes
  - Caractérisation des masques coronographiques
  - Contribution à la caractérisation des plans focaux

⇒ Need of coordination at French level:

- AO4ELT group (ONERA / CNRS)
- EFISOFT